Statistical Power Analysis of Alternative Sampling Designs to Evaluate the Influence of Snake River Hydroelectric Projects on Listed Snail Species

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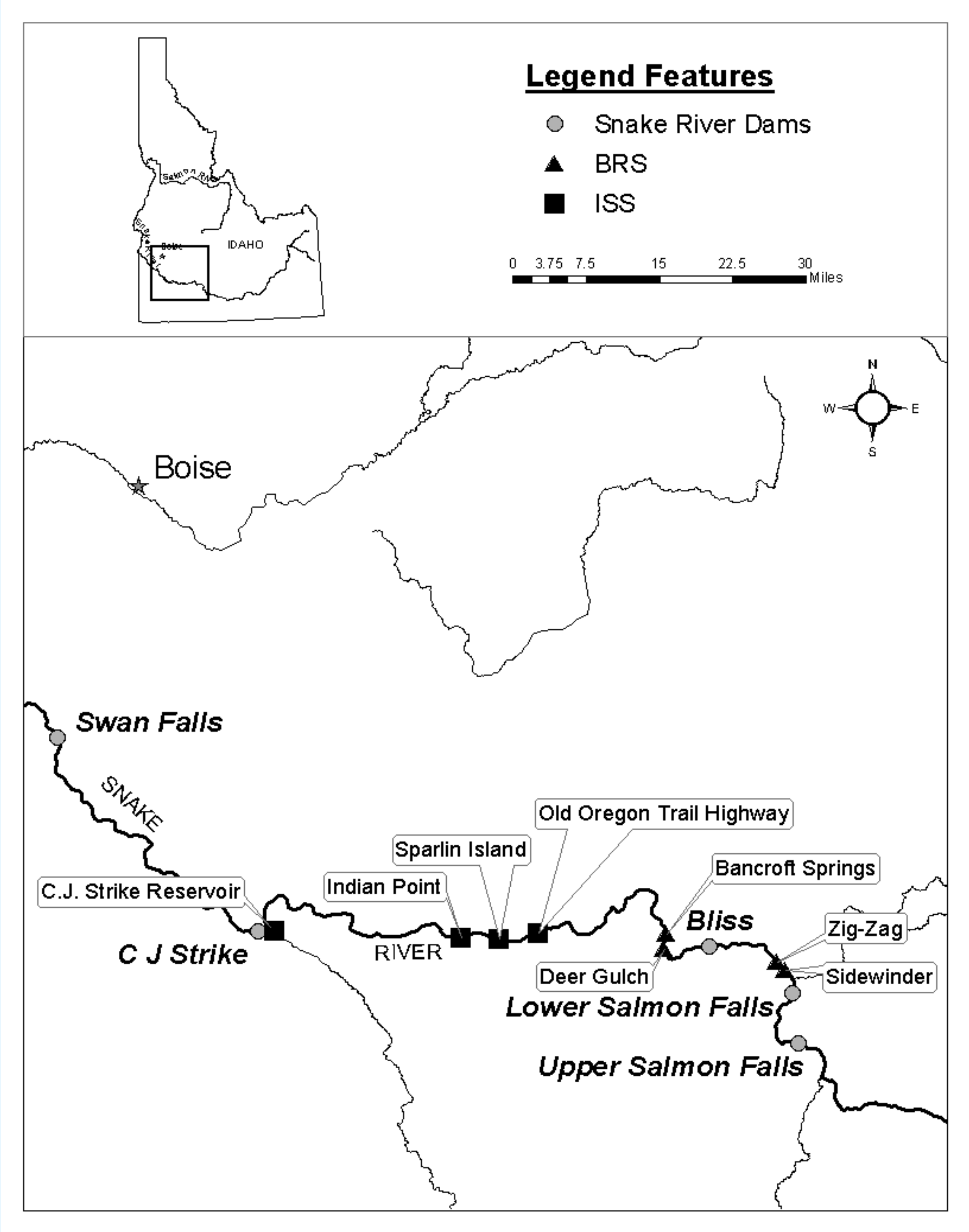
Project goals

- Determine whether Snake River hydroelectric projects negatively influence two listed snail species

  Bliss Rapids snail (BRS), *Taylorconcha serpenticola*
  Idaho springsnail (ISS), *Pyrgulopsis idahoensis*
- Compare snail colonies under run-of-river and load-following operations over 4 years
- Sample 4 ISS sites and 4 BRS sites

2004 Snail sampling sites



ESA Regulatory framework

- Any federally licensed activity must be evaluated for its influence on T & E species
- Initial evaluation to determine if activity harms species
- If so, then larger process of evaluation is triggered

Monitoring goals

"The purposes of this chapter are to provide a means whereby the <u>ecosystems</u> upon which endangered species and threatened species depend may be conserved…"

Endangered Species Act §1531.

Original emphasis on the ecosystem, but in practice ESA assessments typically boil down to counting the numbers of individuals in the endangered species

Outline

- Description of snail collection methods
- Review statistical power and why it’s important
- Compare statistical power of snail density vs. proportional occurrence to detect a change associated with dam operation

Monitoring protocol

- Snails sampled in Snake River from known colonies
- Identified and returned to the field
- Laborious process due to small size and huge numbers of invasive species
- Snail density measured as number of target snails per m^2
- Snail proportional occurrence calculated as the proportion of quadrats with snails present

Snake R. snail sampling – vacuuming snails from the substrate

Snake R. snail sampling – sorting T & E snails

Snake River site

Snake River – Snail assessment

- $0.25\ m^2$ quadrat
- Count all snails
- Idaho Power/USFWS currently use counts of snails to estimate density
- Sample 30 quadrats per site
- Counts are extremely variable
- No standard protocol for ESA assessment, unique to situation and taxa

Statistical power is…

- …the probability of detecting a change when a change truly occurs.
- Statistical power is a function of
  - Variance of the response measure
  - Level of uncertainty (α and β)
  - Sample size
  - Statistical model

Statistical power is …

…the probability of detecting a difference when a difference truly exists.

	H_o false	H_o true
Reject H_o	Correct decision ($1-\beta$)	Type I error (α)
Fail to reject H_o	Type II error (β)	Correct decision

Testing for treatment effects *vs.* Natural resource monitoring

- <u>Treatment effects testing</u>

  Goal is to be sure that the observed difference is real

  Primary concern is with a false positive (α)

- <u>Resource monitoring</u>

  Goal is to be maintain healthy conditions

  Primary concern *should be* false negative (β)

Statistical model for snail monitoring

- Two-sample *t* test
  First sample: Run-of-river year
  Second sample: Load following year
- Estimate variance associated with 1) snail density and 2) proportional occurrence based on 30 quadrats
- Calculate Minimum Detectable Difference (MDD)
- Calculated MDD separately for each site

Minimum detectable difference

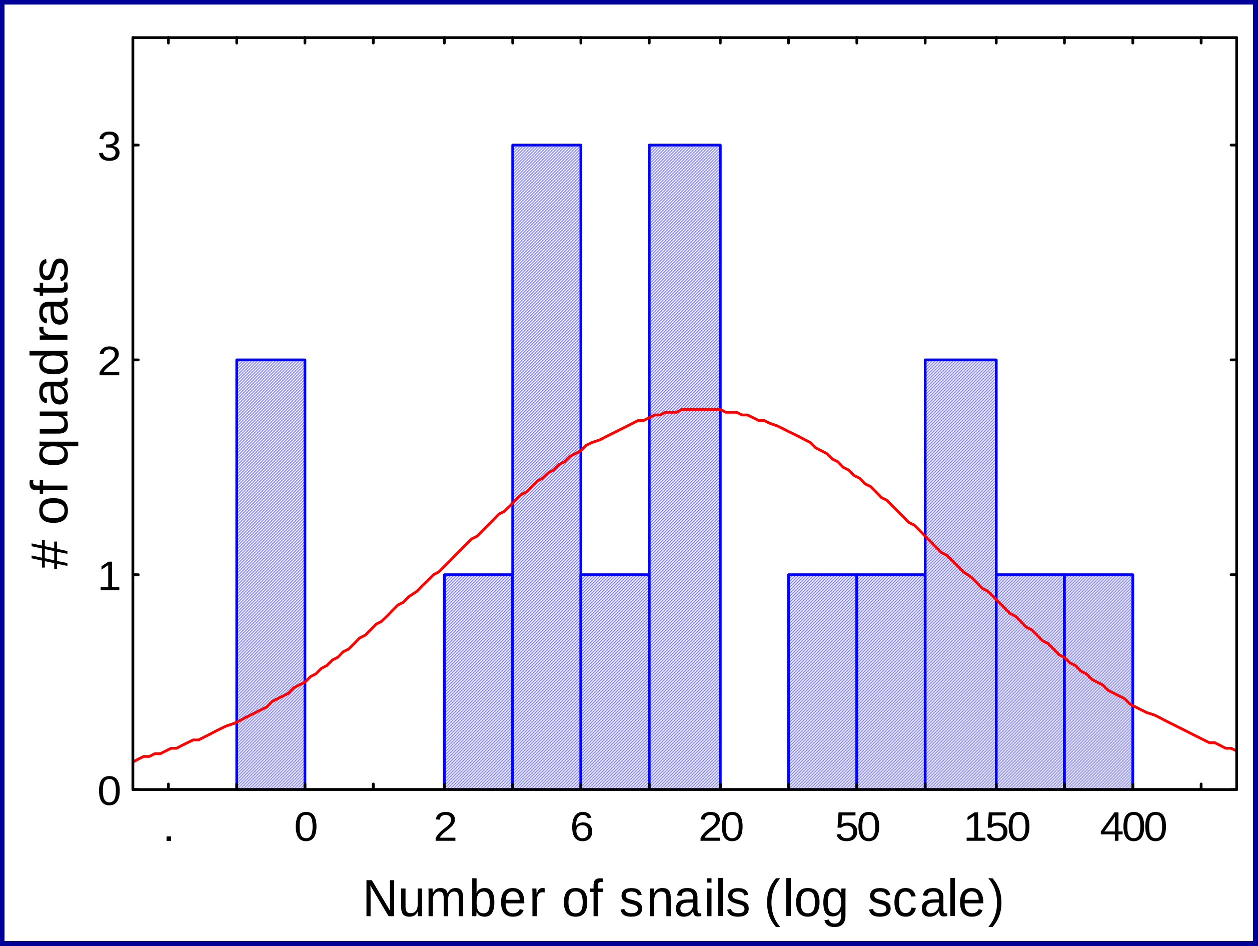
$$\delta \geq \sqrt{2s^2/n}\,(t_\alpha + t_\beta)$$

Prob(Type I error) = Prob(Type II error) = 0.1

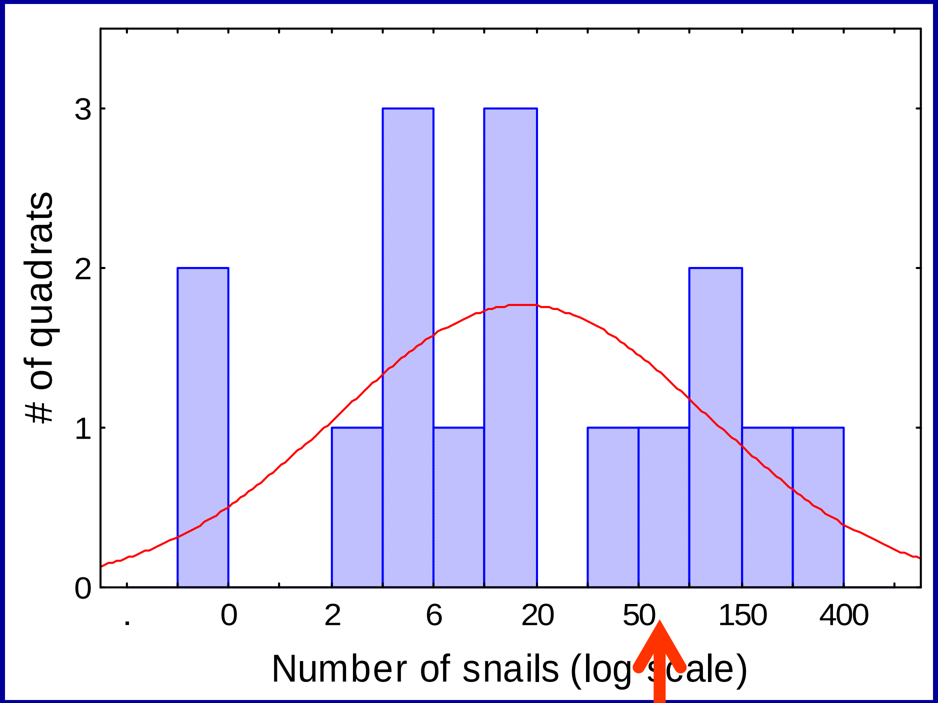
α = β = 0.1

Histogram of log(snail density)

Celebration PT, July 2003

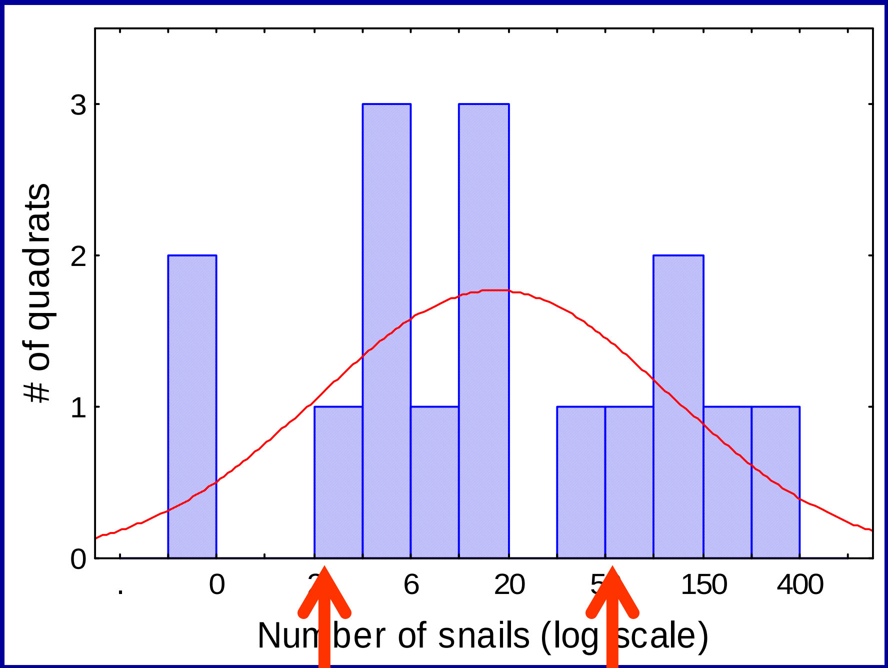


Histogram of log(snail density)
Celebration PT, July 2003



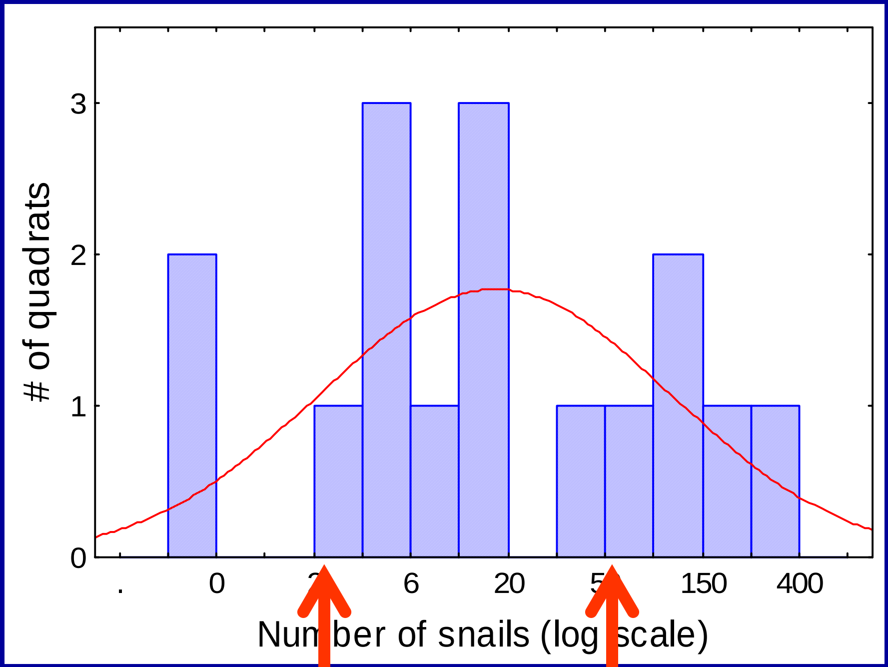
$\mu_{year1} = 59.8$

Histogram of log(snail density)
Celebration PT, July 2003



$\mu_{y2} = 2.24$

$\mu_{y1} = 59.8$



$\mu_{y2} = 2.24$

$\mu_{y1} = 59.8$

MDD

minimum detectable difference

Change needed to represent a significant decline from Year 1 to Year 2 sampling

Site	River Mile	Taxon	$Mean_{Y1}$	$Mean_{Y2}$
CJ Main	495.1	ISS	47.63	16.03
Indian Point	523.3	ISS	0.00	NA
Sparlin Island	527.7	ISS	2.27	0.17
Old Oregon Trail Hwy	531.7	ISS	1.37	0.11
Bancroft Springs	552.8	BRS	7.06	1.25
Deer Gulch	555.2	BRS	7.37	0.00
Zig Zag	568.6	BRS	4.91	0.16
Sidewinder	570.2	BRS	NA	NA

For most sites, probability of detecting even a catastrophic change was very low

Site	Mean_{Y1}	Mean_{Y2}	Reasonable?
CJ Main	47.63	16.03	Yes
Indian Point	0.00	NA	
Sparlin Island	2.27	0.17	No
Old Oregon Trail Hwy	1.37	0.11	No
Bancroft Springs	7.06	1.25	Maybe
Deer Gulch	7.37	0.00	No
Zig Zag	4.91	0.16	No
Sidewinder	NA	NA	

Conclusions – snail density

- For most sites, probability of detecting even a catastrophic change was very low
- Overall, need to see 88% loss in snail density
- Thus, effects of load following would have to be extreme to be detectable, e.g., total loss of snails

Power analysis – proportional occurrence

- Presence/absence data
- Number of quadrats with snail present/total number of quadrats sampled
- Calculate MDD using same model
  - Calculations a bit trickier (Cohen, 1988)
  - Need to stabilize variance (arcsine transform)

For all sites, probability of detecting a reasonable level of change was high

Site	R. Mile	Species	P	Significant change		
				N = 16	***N =30***	***N = 50***
Weiser	345.8	ISS	0.50	0.10	0.17	0.25
Celebr.	446.2	ISS	0.87	0.45	0.55	0.65
Grandview	489.5	ISS	0.93	0.60	0.70	0.80
CJ Strike	495.1	ISS	0.93	0.60	0.70	0.80

Average detectable change: ~37% ~28% ~19%

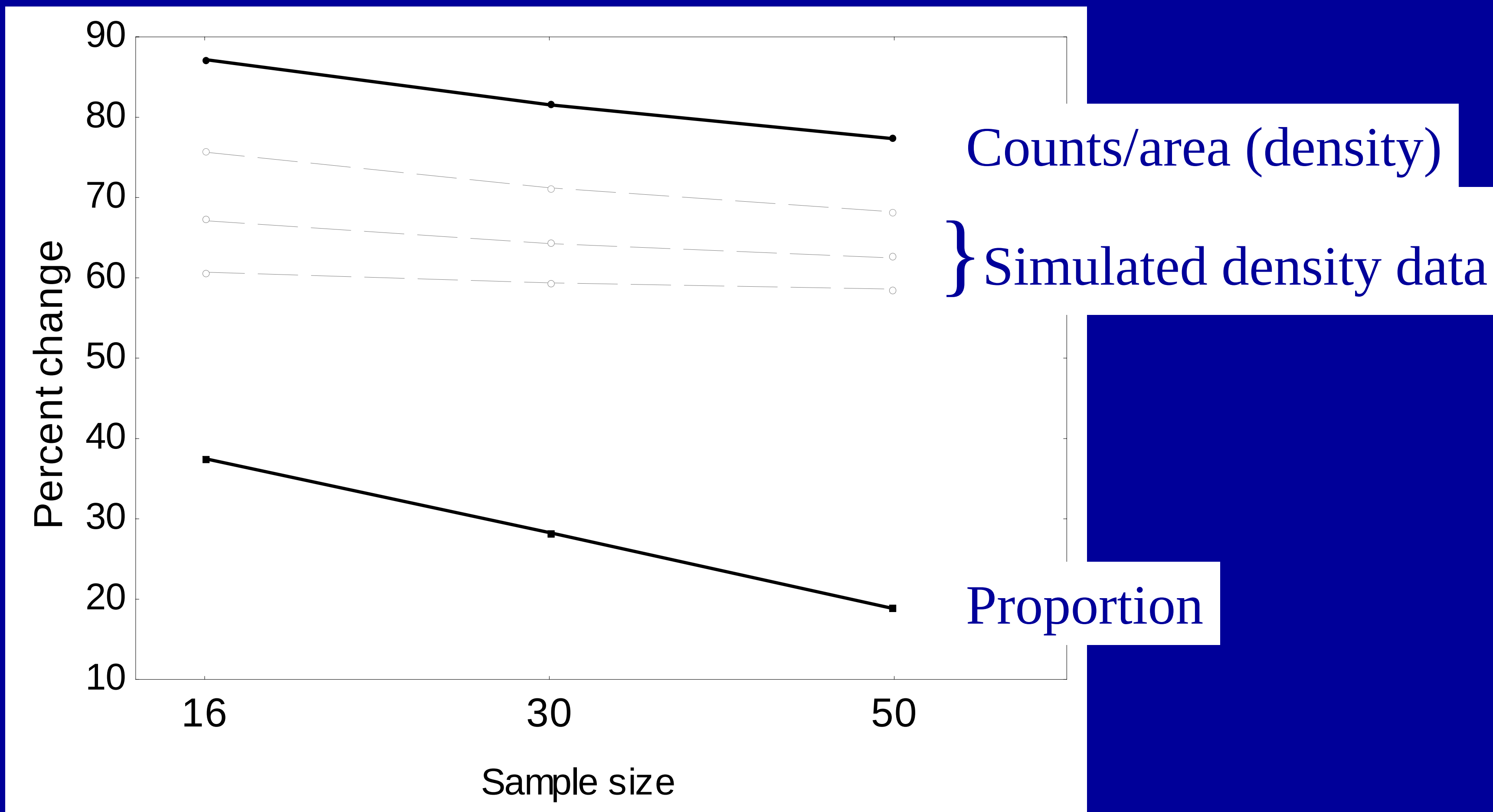
Conclusions – proportional occurrence

- For all sites, probability of detecting a reasonable change was high
- For 30 quadrats, need to see 28% change in proportion to be significant vs. 88% for density
- Presence/absence data quicker to collect than density which needs full counts

Can we improve the sampling design based on density?

- Sample more quadrats
- Increase the quadrat size
- Either approach increases sampling time very quickly

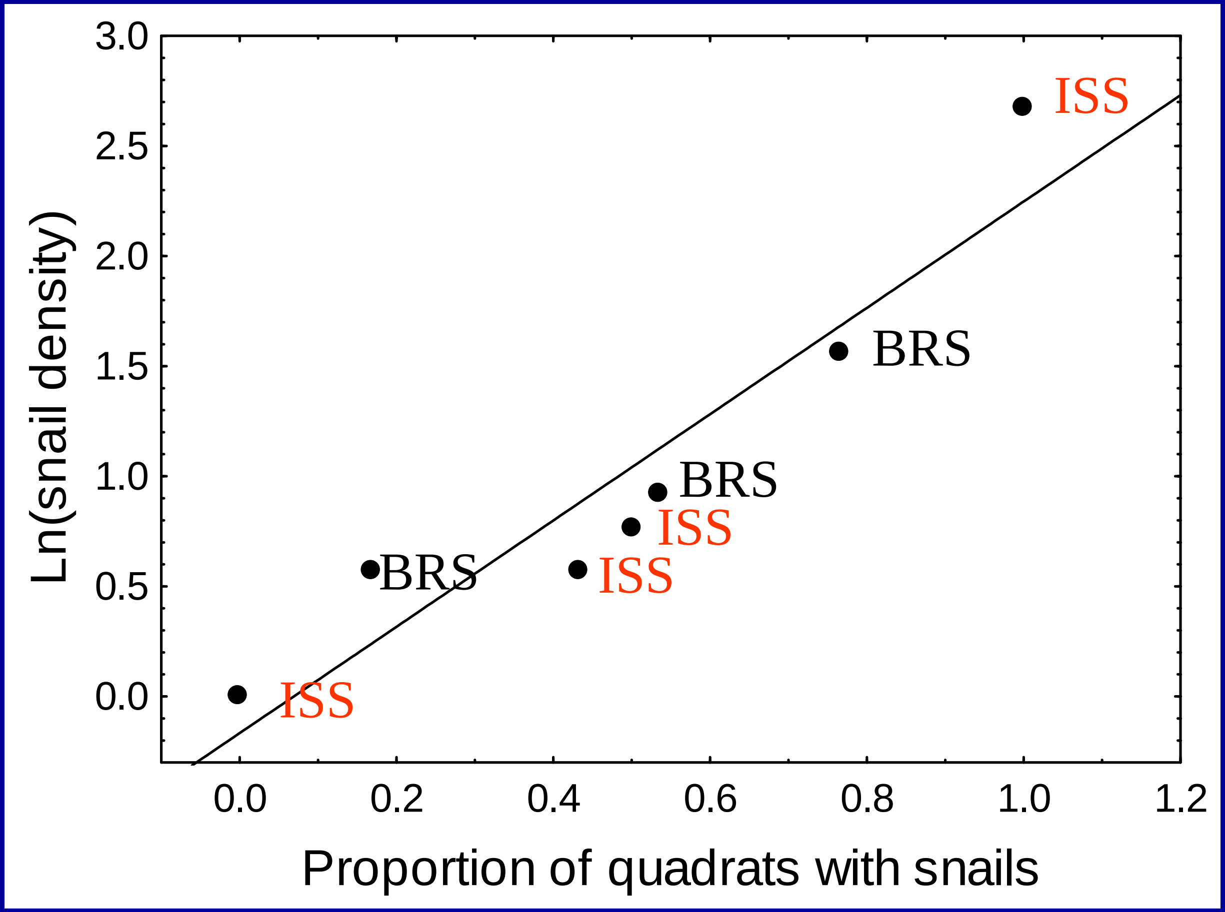
Comparison of precision of the 2 methods



The two methods answer different questions

- Snail density: "*Does the number of snails present change due to LF operation?*"
- Proportion: "*Does the number of quadrats with snails present change due to LF operation?*"
- Proportion more sensitive to change than density
- High correlation between two measures

High correlation between density and proportional occurrence



Summary – Snail monitoring

- Snail density measures may be inadequate to detect differences associated with dam operation
- Very minimal improvement with more quadrats or larger quadrats
- Greatest improvement in power associated with proportion rather than density
- Variability of snail counts not unusual compared to reported values for other species; Extensive literature questioning the ability of population counts to detect change
- Recommend asking the question that you have some reasonable chance of answering

Conclusions – Statistical power analysis

- Key component of an effective monitoring plan
- Connects the purpose of monitoring to data collection
- Often overlooked in resource monitoring
- Consequence of low power is monitoring that fails to protect resource and wastes money
- Ensures that the questions can be answered with the current sampling plan

Acknowledgments

- Thanks to Ralph Myers for project support.
- Thanks to Dave Hopper, Michael Stephenson, Barry Bean, and Aaron Foster for field work, data collection, discussion, and other project support.
- Thanks to the Mid-Snake Technical Workgroup for their interest and suggestions.